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SOME PINEAPPLE PROBLEMS.

10th ARTICLE. - WHY DOES A SOIL BECOME UNSUITABLE?

By Henry C. Henricksen.

Many years ago when the pineapple was extensively cultivated in Florida the fields were frequently left to produce many ratoon crops. When the industry was started in Porto Rico the expectation was that several ratoon crops could be obtained here, but experience soon demonstrated that one, or at the most two, are all that can be relied upon. Many theories have been brought forward to explain this, but there seems to be no experimental data to verify them. Also, the data is very scant regarding the time that must elapse before the land can again be replanted. One of the theories is that a crop leaves certain toxic products in the soil which must be destroyed before another crop will thrive. Whether or not this is correct the fact is that it is difficult to prove. Fortunately, in this case, it is not necessary to prove it for if such toxic products are present they are destroyed by treatments that change the soil in regard to aeration, reaction, and the state of the colloidal matter. Therefore, the measurements for determining a soil's suitability, discussed in former articles, can be used for the soils now under discussion. The proof of this is that in one plantation, with sandy soil, the fields have been replanted twice within the past few years and the present crop is as good as the first one. Similar results have not been obtained in all soils, but the reason for that is explainable.

AERATION. - All soils in which pineapples are grown, in Porto Rico, become more or less packed during the growth of the crop. The degree of such packing depends upon the composition of the soil, the rainfall and the duration of the crop. Therefore, replanting becomes necessary, at intervals, in order that the soil may be broken up and reconditioned in regard to the factor of aeration. Such reconditioning is least necessary in case of sandy soils in which the individual particles are coarse. Next to these are the soils, sandy or clayey, that contain much humus. Also the clay soils in which the crumb structure is exceptionally well developed may retain their permeability for a long time provided the rainfall is not too heavy. The first question is, therefore, will a soil continue to produce as long as it remains permeable, provided the reaction is kept down to a pH well below 6 and provided the colloidal matter is kept in a state of flocculation? The answer is postive,according to the data at hand, but the reservation must be made that the data does not cover enough soil types nor long enough time and, therefore, the final answer cannot be given until later. Of course, the points under discussion refer to soil conditions only. The condition of the plants, after they have produced two to three crops, may not be such that it will be profitable to continue the field, but that point will be discussed in a later article.

The second question is, will a soil produce successive crops of pines provided it is reconditioned once in three to four years and provided that such reconditioning produces the desired effect in regard to aeration, reaction, and state of the colloidal matter? The answer to that question is also positive, but, like the former answer, it is not founded upon sufficient data. The fields,mentioned above, that have been replanted, were left to produce grass or cover crops for at least two years

before replanting. That was necessary, for the land is extremely deficient in humus in many places and with the methods used it could not be reconditioned without an additional supply. But experimental results indicate that the parts in which the humus content is high can be reconditioned in a few months time by proper cultivation. Also, the evidence seems to show, that the parts deficient in humus can be reconditioned in a few months time provided sufficient organic matter is applied. That is to say, humus seems to rectify the unfavorable effect of toxic products, provided such are present. Experiments are now being started for the purpose of showing the effect of humus other than that of improving aeration.

A serious problem in reconditioning the heavier soils is that of implements. The power used for preparing soil has, in general, changed from oxen to tractor, but the implements are the same as those formerly used except, perhaps, a little heavier. That is not satisfactory; in fact, the work is frequently very unsatisfactory, due not alone to the implements but also to the way they are used. Too frequently a soil is plowed when it is too wet or too dry, with the result that it is temporarily made unfit for pineapple growing. Also, the harrowing is seldom satisfactory for in making the surface sufficiently fine the underlaying soil is usually more or less compacted.

Some of the soils in the Manati valley were among the best pineapple soils in the island, when they were first planted, fifteen to twenty years ago. That was due to the well developed crumb structure by means of which aeration was ideal for pineapple plants. Today the crumb structure is entirely destroyed on some of the fields and the production is not remunerative. To leave such expensive land, without producing commercial crops, for a number of years, is a great financial loss. Yet there is no other remedy unless some substitute for organic matter can be found. Of course, there is the alternative of growing cover crops on some cheaper land for use on this, but there still remains the problem of suitable implements. This soil must be handled very carefully in order that the crumb structure may be restored and retained even though it is well supplied with organic matter.

REACTION. - The reaction of the soil solution changes during the growth of the plants, as stated in the fourth article of this series. There is no rule as to what the pH of any particular soil should be, but it must always be low enough to keep the colloidal matter flocculated. That can frequently be accomplished by applying the ammonia and potash in the forms of sulfate. If not, sulfur should be applied in addition to the fertilizers.

Any unfavorable change in the soil will be visible in the plants and it is, therefore, well to inspect the fields frequently. The least turning of color, from dark to a lighter shade, in plants before blooming, indicates abnormality. There may be several causes for this and if one of them is alkalinity a simple test will show it.

FLOCCULATION OF COLLOIDAL MATTER. - When any of the colloidal matter in a soil is in a state of deflocculation, (when it does not settle and leave a clear solution), it may be flocculated with practically any acid or with a number of salts. The amount of acid required depends upon the soil as well as upon the acid used. The following example will illustrate that: Ten grams of a subsoil with pH 5.8 was shaken with 100 cc water. It settled clear in 30 minutes without additions. Portions of a surface soil with pH 6.4 was shaken with 100 cc water and the smallest amount of 1/10 normal acids were added, which would produce a clear solution in one hour. After many trials this was found to be: hydrochloric 1/6 cc, sulfuric 1/3 cc, nitric 1/4 cc, phosphoric 1/2 cc, tartaric 1 cc, citric 2 cc, oxalic 2 cc, acetic 4 cc, tannic 20 cc.

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A serious problem in reconditioning the heavier soils is that of implements. The power used for preparing soil has, in general, changed from mule to tractor, but the implements are the same as those formerly used except, perhaps, a little heavier. That is not satisfactory; in fact, the work is frequently very unsatisfactory, not alone by the implements but also in the way they are used. Too frequently a soil is plowed when it is too wet or too dry, with the result that it is temporarily made unfit for pineapple growing. Also, the harrowing is seldom satisfactory for in making the surface sufficiently fine the underlying soil is usually more or less compacted.

Some of the soils in the Wahiawa valley were among the best pineapple soils in the islands, when they were first planted, fifteen or twenty years ago. That was due to the soil developing crumb structure by means of which aeration was ideal for pineapple plants. Today the crumb structure is entirely destroyed in some of the fields and the production is not remunerative. To leave such important land, without producing commercial crops, for a number of years, is a great financial loss. Yet there is no other remedy unless some substitute for organic matter can be found. Of course, there is the alternative of growing other crops on some such land for use on this. For heavy soil, [illegible] it is evident that such soil must be handled very carefully in order that the crumb structure may be produced and retained even though it is well supplied with organic matter.

REACTION. - The reaction of the soil solution changes during the growth of the plants, as stated in the fourth article of this series. There is no rule as to what the pH of any particular soil should be, but it must always be low enough to keep the colloidal matter flocculated. That can frequently be accomplished by applying the ammonia and potash in the form of sulfates. If not, sulfur should be applied in addition to the fertilizers.

Any unfavorable change in the soil will be visible in the plants and it is, therefore, well to inspect the fields frequently. The least showing of color, from dark to a lighter shade, in plants before blooming, indicates abnormality. There may be several causes for this and if one of them is alkalinity a simple test will show it.

FLOCCULATION OF COLLOIDAL MATTER. - When any of the colloidal matter in a soil is in a state of deflocculation, (when it does not settle but forms a milky solution), it may be flocculated with practically any acid or with a number of salts. The amount of acid required depends upon the acid as well as upon the soil used. The following example will illustrate that: 5 grams of a soil with pH 8.4 was shaken with 100 cc water. It settled clear in 10 minutes [illegible]. Portions of a surface soil with pH 6.4 was shaken with 100 cc water and the smallest amount of 1/10 normal acids were added, which would produce a clear solution in one hour. After many trials this was found to be: hydrochloric 1/5 cc, nitric 1/2 cc, sulfuric 1/4 cc, phosphoric 1/2 cc, tartaric 1 cc, citric 2 cc, acetic 4 cc, [illegible]

Of salicylic and picric only 5 mg. of the solid acids were required, but neither carbolic nor boric acid produced flocculation. Also, it was found that this soil could not be made to settle perfectly clear with any acid until the pH went down to 3.4.

While acids may not be practicable for field use, laboratory experiments with them serve to establish a foundation for field practice. Problems involving colloids are always more or less complicated. In this problem, for instance, the amount of any acid needed depends upon the rate at which it is added. When added in small portions with a time interval, much more will be required than when added all at one time. Although the pH produced by a certain flocculent governs the action, it is very different for different flocculents. As an example, the two soils mentioned above were mixed at the rate of 10 gr. subsoil to 90 gr. surface soil after which the mixture was shaken with 500 cc water. It settled clear in one hour and the pH was 6. whereas with the acids it had to be pH 3.4 or below. That such changes also take place in the soil is illustrated by the fact that where this subsoil is thrown up from drainage ditches onto a top soil, which does not settle clear nor produce vigorous plants, the pH changes, the soil solution settles clear, and the plants become thrifty.

SULPHUR. - In this investigation sulphur has, so far, been found to be the most practicable material to use for correcting alkalinity and deflocculation. It can be used on any soil as it has no ill effect upon the soil itself. Neither has it an ill effect upon crops succeeding pineapples, for the acid produced leaches away inside of a year if the rainfall is heavy. For the purpose of testing the effect of sulphur on pineapple plants, experiments were started in March 1922. The soil ranged from light sand to heavy clay with some plats of very good soil containing much humus. The plants were six months old and vigorous in all the plats although more so in the better soils. Sulphur was applied between the plants at the minimum rate of 1,000 lbs. per acre, rising to the maximum rate of 6,000 lbs. per acre. The pH of the soil solution in the different plats ranged from 6 to 6.2. After two months the following changes were observed: In plats with 1,000 lbs. per acre there were a few mole crickets present and also a few weeds. In plats with 2,000 lbs. per acre there were scarcely signs of mole crickets and the weeds had all disappeared. In plats with applications larger than 2,000 lbs. there were neither weeds nor signs of mole crickets although both were very abundant in the check plats.

The extent to which the plants were damaged by the sulphur varied according to the amount applied as well as to the character of the soil. No apparent damage was caused by 2,000 lbs. per acre on any of the plats. The plant roots were damaged by applications larger than 2,000 lbs., but in plats with good soil containing much humus the damage was less than in light sand or heavy clay.

Of salicylic and picric acid, [illegible] were required, but neither carbolic nor [illegible] produced [illegible]. Also, it was found that the soil could not be made to [illegible] permanently, since [illegible] would [illegible] to 3.5.

Soils which may not be [illegible] for field use, laboratory experiments with them serve to establish a foundation for field practice. Practical [illegible] soils are plots were of some complication. It is a question, for instance, [illegible] the amount of [illegible] depends upon the form in which it is added. When added in small [illegible], more [illegible] will be required than [illegible] at one time. Although the [illegible] produced by a certain [illegible] governs the acidity, it is [illegible] to [illegible]. For example, [illegible] when sulphur [illegible] was [illegible] 500 lbs. per acre. It [illegible] the pH [illegible] to be pH [illegible]. That [illegible] in the soil is illustrated by the fact that [illegible] up from [illegible] the soil, [illegible] vigorous growth, [illegible] the soil solution [illegible], but the plants [illegible] dry.

Sulphur. – [illegible] elemental sulphur has, so far, been found to be the most [illegible] material to use for increasing acidity [illegible]. It can be [illegible] only [illegible] the soil. However, [illegible] effect upon crops [illegible], for the acid produced [illegible] of sulphur if [illegible]. For the purpose of studying the effect of [illegible] of elemental sulphur, [illegible] plots were [illegible], the soil ranged from light sand to heavy clay with [illegible]. The plants were [illegible] in the latter soils. Sulphur was applied [illegible] at the [illegible] rate of 1,000 lbs. per acre, rising to [illegible] rate of 8,000 lbs. per acre. The pH of the soil solution in the different plots ranged from 4 to 6.5. [illegible] changes were observed. In plots with 4,000 lbs. [illegible] the plants [illegible] a few weeks. In plots with 6,000 lbs. per acre [illegible] scarcely [illegible] the plants had all disappeared. [illegible] applications larger than 8,000 lbs., [illegible] the plants were not injured in the check plots.

The amount to which the plants were injured by the sulphur varied according to the amount applied as well as the character of the soil. No apparent injury was caused by 2,000 lbs. per acre on any of the plots. The plants were injured by applications larger than 2,000 lbs., but in plots with good [illegible] [illegible] the damage was less than in plots with [illegible].

Two months later the conditions were practically unaltered and again two months later, (six months after the application), there was not much change. The plants in the most heavily sulfured plats made the least growth, but those in the plats receiving 1,000 lbs. and 2,000 lbs. per acre were superior to the checks. The pH changed as follows: In plats with 1,000 lbs. it was 3.6 inside of two months and it was that at the end of three months, but in four months it was down to 3. This indicates that all of the sulfur was not oxidized until that time.

In all of the other plats the pH was 2.8 inside of two months and it kept at that point the following four months, except in one plat, with poor sandy soil, which received 5,000 lbs. per acre, in that it went down to 2. After six months the pH rose gradually in some of the plats and after twelve months it was back to 6.2 in all of them except in the poor sand, mentioned above, where it was 5.8, showing that the acid had practically all disappeared.

Since that time many experiments have been made with sulfur in various soils and it has been found to cause no damage to the plants when applied at the rate of half a ton to one ton per acre. It has been found to be a fairly good weed eradicator when used at the rate of one ton per acre and that amount also discourages the mole crickets for a period of six to eight months. Also when applied at that rate sulfur has been found to check the ravage of nematodes. The extent of damage caused by them cannot readily be ascertained with the pineapple plant, but they are very destructive to the garden dahlia and as that plant is acid tolerant it has been found possible to grow it in heavily nematode infested soil as long as the pH is kept down to about 5.

SUMMARY. - The reason why a soil becomes unsuitable for pineapple growing may be that the physical condition of it changes to such a degree that aeration is impeded. It also may be that the reaction changes and the colloidal matter becomes deflocculated, but usually it is a combination of all the factors mentioned.

There are several degrees of unsuitability. One is where the pineapple crop cannot be continued, although another crop may be planted after a few months when the soil has been reconditioned. Another is where small amounts of organic matter, such as that supplied by one cover crop, will be required. A third is where large amounts of organic matter, or some other material that will lighten the soil, is required together with careful and scientific cultivation.

The pH and deflocculation are never serious problems for they can be remedied by correct fertilization; by subsoiling where the subsoil is in the proper condition and when it can be done cheap enough; and also by an application of sulfur. How to determine the amount of sulfur needed on a certain soil and under certain conditions has not been definitely worked out, but it undoubtedly will be soon. Sulfur at the rate of half a ton per acre or less will usually be sufficient. If upwards of a ton is used much benefit may be received from a lessening of insects and weeds.